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**APPLICATION
FOR
UNITED STATES
LETTERS PATENT**

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FOR: SEMICONDUCTOR CIRCUIT IN
WHICH POWER CONSUMPTION IS
REDUCED AND SEMICONDUCTOR
CIRCUIT SYSTEM USING THE SAME

DOCKET NO.: 01USFP644-M.K.

106250-8856860

**SEMICONDUCTOR CIRCUIT
IN WHICH POWER CONSUMPTION IS REDUCED AND
SEMICONDUCTOR CIRCUIT SYSTEM USING THE SAME**

Background of the Invention

1. Field of the Invention

The present invention relates to a semiconductor circuit, in which power consumption can be reduced, and a semiconductor circuit system using the same.

2. Description of the Related Art

Display apparatuses such as a liquid crystal display apparatus and a plasma display apparatus are widely used. In such a display apparatus, it is desired to reduce power consumption.

Fig. 1 shows the structure of a conventional liquid crystal display apparatus. Referring to Fig. 1, the conventional liquid crystal display apparatus 101 is composed of a display device 102, a vertical drive unit 103 and a horizontal drive unit 104.

The display device 102 is a liquid crystal panel section which is conventionally known. The liquid crystal panel section has X rows of gate bus lines (not shown) extending in a horizontal direction and Y columns of data bus lines (not shown) extending in a vertical direction. A plurality of pixels are provided in areas surrounded by those lines. Each

5 connected with the gate bus line, a source thereof is
connected with the data bus line, and a drain thereof
is connected with the pixel electrode.

10 104 has a function to control the voltage level of
each of the data bus lines.

The vertical drive unit 103 scans gate bus lines from
15 the top line to the bottom line, and the horizontal
drive unit 104 controls the voltage level of the data
bus line connected with the pixel based on pixel data.
Thus, the pixel which is connected with the gate bus
line scanned by the vertical drive unit 103 can
20 display the pixel data.

Fig. 2 shows the structure of the horizontal drive unit 104. Referring to Fig. 2, the horizontal drive unit 104 is composed of a plurality of horizontal drive circuits 111-h ($h = 1, 2, 3, \dots, n$) which are connected with an input terminal 112. When the voltage level of an input signal D101 supplied from the input terminal 112 is high, all the

horizontal drive circuits 111-h are driven and activated

Fig. 3 shows the structure of the conventional horizontal drive circuit 111-h. Referring to Fig. 3, the conventional horizontal drive circuit 111 is composed of a first differential input circuit 113, a second differential input circuit 114, a third differential input circuit 118, a first register circuit 115 and a second register circuit 116. Also, the conventional horizontal drive circuit 111-h has a start pulse input terminal 119 to which a start pulse signal is supplied, and a start pulse output terminal 120 to output the start pulse signal. The start pulse signal is used to establish synchronization when the first register circuit 115 and the second register circuit 116 take in data signals D102b and D102c.

The first differential input circuit 113 is connected with the input terminal 112, clock signal input terminals D102a-1 and D102a-2 and a plurality of flip-flops 115-i ($i = 1$ to j) of the first shift register circuit 115. The first differential input circuit 113 operates when the voltage value of the input terminal 112 is V_B ($V_B > 0$). The clock signal D102a is supplied to the first differential input circuit 113 from the clock signal input terminals D102a-1 and D102a-2. Also, when the clock signal D102a is supplied, the first differential input

circuit 13 supplies the clock signal D102a to the plurality of flip-flops 115-1.

1 The second differential input circuit 114 is connected with the input terminal 112, data signal
5 input terminals D102b-1 and D102b-2 and first data registers 116a of the second register circuit 116. The first data signal D102b is supplied from the data signal input terminals D102b-1 and D102b-2 to the
10 second differential input circuit 114. The second differential input circuit 114 is activated when the voltage value of the input terminal 112 is VB ($VB > 0$). Also, the second differential input circuit 114 supplies a signal corresponding to the first data
15 signal D102b to the first data registers 116a when the first data signal D102b is supplied.

20 The third differential input circuit 118 is connected with the input terminal 112, data signal input terminals D102c-1 and D102c-2 and the second data registers 116b of the second register circuit
25 D102c-2. The third differential input circuit 118 is activated when the voltage value of the input terminal 112 is VB ($VB > 0$). The second data signal D102c is supplied to the third differential input circuit 113 from the data signal input terminals D102c-1 and
118 supplies the second data signal D102c to the second data registers 116b when the second data signal

The first register circuit 115 is connected with the first differential input circuit 113, the start pulse input terminal 119 and the start pulse output terminal 120.

The first register circuit 115 is composed of the plurality of flip-flops 115-1. Also, the flip-flops 115-1 are connected with the first differential input circuit 113. Moreover, each of the flip-flops 115 is connected with a corresponding one of sets of a first data register 116a and a second data register 116b in the second register circuit 116. The plurality of flip-flops 115-1 are cascade-connected to form a shift register, and delays the start pulse signal one clock by one clock. The start pulse input terminal 119 is connected with the flip-flop 115-1 as the first end of this cascade connection, and the start pulse output terminal 120 is connected with the flip-flop 115-(j-1).

First, the start pulse signal is supplied from the start pulse input terminal 119 to the flip-flop 115-1. Then, the clock signal D102a is supplied from the first differential input circuit 113 to each of the flip-flops 115-i. When the start pulse signal is supplied, the flip-flop 115-1 generates one pulse

signal in response to the rising edge of the clock
signal D102a and supplies the pulse signal to the
corresponding set of the first data register 16a and
the second data register 116b. Then, the flip-flop
5 115-1 outputs a shift signal to the flip-flop 115-2 as
a next flip-flop before a next pulse of the clock
signal D102a rises up.

Also, when the shift signal is supplied from
the flip-flop 115-(p-1) (p is an integer to satisfy 2
10 $\leq p \leq j-1$), the flip-flop 115-p generates one pulse
signal, and supplies the pulse signal to the
corresponding set of the first data register 116a and
the second data registers 116b. Then, the flip-flop
115-p outputs a shift signal to the flip-flop 115-
15 (p+1) before a next pulse of the clock signal D102a
rises up.

Also, when a shift signal is supplied from the
flip-flop 115-(j-2), the flip-flop 115-(j-1) generates
one pulse signal, and supplies the pulse signal to the
20 corresponding set of the first data register 116a and
the second data register 116b. Also, the flip-flop
115-(j-1) outputs a shift signal to the flip-flop 115-
j and the start pulse output terminal 120 before a
next pulse of the clock signal D102a rises up.

25 In addition, when a shift signal is supplied
from flip-flop 115-(j-1), the flip-flop 115-j
generates one pulse signal, and supplies the pulse

signal to the corresponding set of the first data register 116a and the second data register 116b which are connected with the flip-flop 115-j.

The second register circuit 116 is connected with the second differential input circuit 114, the third differential input circuit 118 and the first register circuit 115. The second register circuit 116 is composed of register sections 116c for the same number as the number of flip-flops 115-1. Here, each of the register sections 116c is composed of the first data register 116a and the second data register 116b. The respective register sections 116c are connected with the flip-flops 115-1, respectively.

Next, an operation of each register section 116c will be described below. First, the pulse signal is supplied from the flip-flop 115-1 to a corresponding one of the register sections 116c, respectively. The first data register 116a in the corresponding register section 116c latches a signal corresponding to the first data signal D102b supplied from the second differential input circuit 114 at the timing of the pulse signal supplied from the corresponding flip-flop 115-1. Also, the second data register 116b in the corresponding register section 116c latches a signal corresponding to the second data signal D102c supplied from the third differential input circuit 118 at the same timing.

Next, an operation of the horizontal drive circuit 111 will be described below. The start pulse signal is supplied from the start pulse input terminal 119 and is delayed by the flip-flops 115-1 as the shift register in response to the edge of the clock signal D102a outputted from the first differential input circuit 113. The data signal corresponding to the data signal D102b is outputted from the second differential input circuit 114 in synchronous with the clock signal D102a. Each data register 116a latches the data signal at the timing of the rising edge of the pulse signal from the flip-flop 115-1.

As described above, when the conventional horizontal drive unit 104 operates, all the horizontal drive circuits 111-h are driven. Also, all the differential input circuits 113, 114 and 118 of the horizontal drive circuit 111-1 are activated.

Here, in the conventional horizontal drive circuit, each of the differential input circuits 113, 114 and 118 requires the time of about 500 nanoseconds for a stable operation after the differential input circuit is activated. Also, the time of about 300 nanoseconds is needed to latch the data signals D102b and D102c. For this reasons, in the conventional liquid crystal display apparatus, all the horizontal drive circuits 111-h are driven at the same time for the stable operation of the horizontal drive unit.

5 integrated circuit is composed of an input/ output
interface which inputs and outputs a signal having a
smaller amplitude voltage than a power supply voltage
in synchronous with a clock signal. A first input
circuit of the input/output interface receives an
10 external clock signal and is composed of differential
MOSFETs having a gate to which the small amplitude
signal and a reference voltage having a level of a
half of the small amplitude, and a current source
MOSFET connected to common sources of the differential
15 MOSFETs and operating in an ordinary state. Thus, the
first input circuit produces an internal signal having
amplitude corresponding to the power supply voltage
from the small amplitude signal. A second input
circuit of the input/output interface receives the
20 small amplitude signal in synchronous with the
external clock signal and is composed of differential
MOSFETs having a gate to which the small amplitude
signal and a reference voltage having a level of a
half of the small amplitude, an input section
25 including a current source MOSFET connected to common
sources of the differential MOSFETs and operating
intermittently based on an internal clock signal taken

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differential input amplifier, and a second power switch transistor which supplies a lower power supply voltage to the differential input amplifier. A control circuit turns on the first and second power switch transistors in synchronous with a first state of the synchronous clock signal to activate the differential input buffer and to set the latch circuit to an input enable state, and turns off the first and second power switch transistors in synchronous with a second state of the synchronous clock signal to inactivate the differential input buffer and to set the latch circuit to a data latched state.

Summary of the Invention

15 Therefore, an object of the present invention is to provide a semiconductor circuit, in which it is possible to reduce power consumption, and a semiconductor system using the same.

20 Another object of the present invention is to provide a semiconductor circuit in which a stable horizontal driving operation is possible and a semiconductor system using the same.

Still another object of the present invention is to provide a semiconductor circuit whose size can be reduced, and a semiconductor system using the same.

In an aspect of the present invention, a semiconductor circuit system includes a first signal

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of the n circuit sections which is connected to the circuit section.

Also, the n circuit sections may be provided for different the semiconductor chips, respectively.

5 Also, each of the n circuit sections may include a plurality of differential input circuits, a plurality of register circuits connected to output terminals of the plurality of differential input circuits, respectively, and a control circuit
10 connected with at least one of the plurality of register circuits as a specific register circuit and the plurality of differential input circuits. The specific register circuit executes a predetermined operation using a first signal outputted from a
15 corresponding one of the plurality of differential input circuits, and outputs a second signal to the latch circuit when the operation ends. The control circuit activates the plurality of differential input circuits in response to a third signal to operate and
20 stops the operations of the plurality of differential input circuits in response to the second signal.

Also, the plurality of register circuits may include at least one set of registers and at least one set of data registers, and the specific register
25 circuit includes the set of registers.

Also, each of the registers may output a pulse signal to a corresponding one of the data

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5 register. The last one of the registers outputs the first signal as the second signal.

10 reset in response to the second signal latched by the
first latch, and a switch which activates the
plurality of differential input circuits when the
second latch is set and inactivates the plurality of
differential input circuits when the second latch is
15 reset.

20 plurality of differential input circuits, respectively,
and a control circuit connected with at least one of
the plurality of register circuits as a specific
register circuit and the plurality of differential
input circuits. The specific register circuit
25 executes a predetermined operation using a first
signal outputted from a corresponding one of the
plurality of differential input circuits, and outputs

5 a second signal to the latch circuit when the operation ends. The control circuit activates the plurality of differential input circuits in response to a third signal to operate and stops the operations of the plurality of differential input circuits in response to the second signal.

10 Here, the plurality of register circuits may include at least one set of registers and at least one set of data registers, and the specific register circuit includes the set of registers.

15 Also, each of the registers outputs a pulse signal to a corresponding one of the data registers when the first signal is supplied, such that data are written in a corresponding one of the data registers, and propagates the first signal to a next one of the registers which is connected to the register. The last one of the registers outputs the first signal as the second signal.

20 Also, the control circuit may include a first latch which latches the second signal, a second latch which is set in response to the third signal and is reset in response to the second signal latched by the first latch, and a switch which activates the plurality of differential input circuits when the second latch is set and inactivates the plurality of differential input circuits when the second latch is reset.

Brief Description of the drawings

Fig. 1 is a block diagram showing the structure of a conventional liquid crystal display apparatus;

Fig. 2 is a diagram showing the structure of a horizontal drive unit;

Fig. 3 is a block diagram showing the structure of a conventional horizontal drive circuit;

Fig. 4 is a block diagram showing the structure of a semiconductor circuit system according to a first embodiment of the present invention;

Figs. 5A to 5K are timing charts showing an operation of the semiconductor circuit system according to the first embodiment of the present invention;

Fig. 6 is a block diagram showing the structure of a semiconductor circuit in the system according to the first embodiment of the present invention;

Fig. 7 is a circuit diagram showing the structure of a differential input circuit in the semiconductor circuit according to the first embodiment of the present invention;

Fig. 8 is a block diagram showing the structure of the semiconductor circuit according to a second embodiment of the present invention;

Figs. 9A to 9G are timing charts showing an operation of the semiconductor circuit system according to the second embodiment of the present

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invention;

Fig. 10 is a block diagram showing the structure of the semiconductor circuit system according to a third embodiment of the present

5 invention; and

Figs. 11A to 11K are timing charts showing an operation of the semiconductor circuit system according to the third embodiment of the present invention.

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Description of the Preferred Embodiments

Hereinafter, a semiconductor circuit system using semiconductor circuits of the present invention will be described with reference to the attached

15 drawings. Although the present invention is applied to a horizontal drive type of display apparatus such as a liquid crystal display apparatus and a plasma display monitor, the application of the present invention is not limited to the display apparatus.

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Fig. 4 is a diagram showing the structure a semiconductor circuit system according to the first embodiment of the present invention. Referring to Fig. 4, the horizontal drive type of semiconductor circuit system 1 according to the first embodiment of

25 the present invention is composed of a plurality of semiconductor circuits (chips) 2-1 (1=1, 2, ..., n: n is an integer equal to or more than 3). Each

semiconductor circuit 2 has an input terminal 3-i and an output terminal 4-i.

The first input terminal 3-1 of the semiconductor circuit 2-1 and the first input terminal 3-2 of the semiconductor circuit 2-2 are connected with a first external terminal 5 to which a control signal D1 is externally supplied. The output terminal 4-1 of the semiconductor circuit 2-1 is connected with the input terminal 3-3 of the semiconductor circuit 2-3. The output terminal 4-2 of the semiconductor circuit 2-2 is connected with the input terminal 3-4 of the semiconductor circuit 2-4. Thus, the output terminal 4-m of the semiconductor circuit 2-m ($1 \leq m \leq n-2$) is connected with the input terminal 3-(m+2) of the semiconductor circuit 2-(m+2).

Also, each of the semiconductor circuits 2-i is connected with a second external terminal 6 having the voltage level of VB ($VB > 0$). The control signal D1 is outputted from the output terminal 4-m of the semiconductor circuit 2-m and is supplied to the input terminal 3-(m+2) of the semiconductor circuit 2-(m+2). Also, although it is not shown, a data signal and a clock signal are externally supplied to each of the semiconductor circuits 2-i.

Next, an operation of the semiconductor circuit system according to the first embodiment of the present invention will be described. Figs. 5A to 5K

are time charts showing the operation of the semiconductor circuit system in the first embodiment.

Referring to Figs. 5A to 5K, a pulse signal P1 is supplied from the first external terminal 5 to the semiconductor circuit system 1. The semiconductor circuits 2-1 and 2-2 are activated in response to the rising edge of the pulse signal P1. When a data writing operation for a predetermined time is ended, the semiconductor circuit 2-1 outputs a pulse signal P2 from the output terminal 4-1 and then pauses or stops the operation. The semiconductor circuit 2-3 is activated in response to the rising edge of the pulse signal P2. When a data writing operation is ended, the semiconductor circuit 2-2 outputs a pulse signal P3 from the output terminal 4-2 and then pauses or stops the operation. The semiconductor circuit 2-4 is activated in response to the rising edge of the pulse signal P3. In the same way, when a data writing operation is ended, the semiconductor circuit 2-m outputs a pulse signal P(m+1) from the first output terminal 4-m and then pauses or stops the operation. The semiconductor circuit 2-(m+2) is activated in response to the rising edge of a pulse signal P(m+1). Also, when a data writing operation is ended, the semiconductor circuit 2-m pauses or stops the operation.

In the semiconductor circuit system according

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to the first embodiment of the present invention, at most two semiconductor circuits are driven at a time.

Fig. 6 shows the structure of the semiconductor circuit 2-1. Referring to Fig. 6, the semiconductor circuit 2 is composed of a latch circuit 11, a switch section 12-1, a first differential input circuit 13, a second differential input circuit 14, a third differential input circuit 18, a first register circuit 15, a second register circuit 16 and a flip-flop circuit 19.

Also, the semiconductor circuit 2-1 has a start pulse input terminal 7 to which the start pulse signal is supplied, and a start pulse output terminal 8 to output the start pulse signal.

Referring to Figs. 4 and 6, the start pulse input terminal 7 of the semiconductor circuit 2-1 is connected with of the start pulse output terminal 8 of the semiconductor circuit 2-(i-2), and the start pulse output terminal 8 of the semiconductor circuit 2-1 is connected with the start pulse input terminal 7 of the semiconductor circuit 2-(i+2). However, when the semiconductor circuits are cascade-connected in series, the start pulse input terminal 7 of the semiconductor circuit 2-1 may be connected with of the start pulse output terminal 8 of the semiconductor circuit 2-(i-1), and the start pulse output terminal 8 of the semiconductor circuit 2-1 may be connected with

the start pulse input terminal 7 of the semiconductor circuit 2-(i+1). A start pulse signal is supplied to the start pulse input terminal and used to establish synchronization when data signals D2b and D2c are taken in the second register circuit 16.

The latch circuit 11 is connected with the first input terminal 3 of the semiconductor circuit 2-i, the flip-flop circuit 19 and the switch section 12. The latch circuit 11 receives the control signal D1 from the input terminal 3 and the output D3 of the latch circuit 11 is set to the voltage level VA (a bias voltage and $VA > 0$) of the control signal D3. Also, the latch circuit 11 receives a control signal D4' from the flip-flop circuit 19 and the output D3 of the latch circuit 11 is reset to the zero voltage level.

The switch section 12 is connected with the latch circuit 11 and a node D5. The node D5 is connected with the switch section 12, the first differential input circuit 13, the second differential input circuit 14 and the third differential input circuit 18. Also, the switch section 12 is connected with the second external terminal 6 having the potential of VB ($VB > 0$) and the ground potential 17. The switch section 12 connects the node D5 and either of the second external terminal 6 and the ground potential 17 in response to the control signal D3. In

this embodiment, when the voltage level of the control signal D3 is VA, the switch section 12 connects the node D5 and the second external terminal 6 to set the voltage level of the node D5 to VB. Also, when the voltage level of the control signal D3 is zero potential, the switch section 12 connects the node D5 and the ground potential 17 to set the voltage level of the node D5 to zero. Thus, the supply of the clock signal is controlled by the control signal D3.

The first differential input circuit 13 is connected with clock signal input terminals D2a-1 and D2a-2, the node D5 and a node D6. The node D6 is connected with the first differential input circuit 13, the plurality of flip-flop 15-1 of the first shift register circuit 15, and the flip-flop circuit 19.

The clock signal D2a is supplied from the clock signal input terminals D2a-1 and D2a-2 to the first differential input circuit 13. The first differential input circuit 13 is activated to start the operation when the voltage level of the node D5 is VB, and stops the operation when the voltage level of the node D5 is zero. Also, the first differential input circuit 13 supplies the node D6 with the clock signal D2a when the clock signal D2a is supplied.

The first data signal D2b is supplied from the data signal input terminals D2b-1 and D2b-2 to the second differential input circuit 14. Also, the

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The first register circuit 15 is connected with the output terminal 4, the node D6, the start pulse input terminal 7, the start pulse output terminal 8 and the flip-flop circuit 19. The first register circuit 15 is composed of the plurality of flip-flops 15-1. Also, each of the flip-flops 15-1 is connected with the node D6. Moreover, each of the flip-flops 15-1 is connected with the set of the first data register 16a and the second data register 16b in the second register circuit 16. In addition, the plurality of flip-flops 15-1 are cascade-connected to delay the start pulse signal one clock by one clock. The flip-flop 15-1 as the first end of this cascade connection is connected with the start pulse input terminal 7. Also, the flip-flop 15-j as the last one of this cascade connection is connected with the output terminal 4 and the flip-flop circuit 19. Moreover, the start pulse output terminal 8 is connected with the node D7 between the flip-flop 15-(j-1) and the flip-flop 15-j.

First, when the operation of the first differential input circuit 13 is stable, the first

Also, when a shift signal is supplied from the

15 flip-flop 15-(p-1) (p is an integer satisfying $2 \leq p \leq j-1$), the flip-flop 15-p generates one pulse signal, and supplies the pulse signal to the set of the first data register 16a and the second data register 16b which are connected with the flip-flop 15-p. Next, the

20 flip-flop 15-p outputs a shift signal to the flip-flop 15-(p+1) before a next pulse of the clock signal D2a rise up.

When a shift signal is supplied from the flip-flop 15-(j-2), the flip-flop 15-(j-1) generates one pulse signal, and supplies the pulse signal to the set of the first data register 16a and the second data register 16b which are connected with flip-flop 15(j-

5 from the start pulse output terminal 8 and is supplied

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10 generates one pulse signal, and supplies the pulse
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20 third differential input circuit 18 and the first

25 composed of one first data register 16a and one second

5 Next, an operation of each register section 16c
will be described below. First, a pulse signal is
supplied from the flip-flops 15-1 which are connected
with the register section 16c. The first data signal
D2b is supplied from the second differential input
10 circuit 14 at the timing of the pulse signal and is
latched by the first data registers 16a of the
register section 16c. Also, the second data signal is
supplied from the third differential input circuit 18
D2c and is latched by the second data register 16b of
15 the register section 16c.

As shown in the above, the latch 11 receives
25 the control signal D1 from the input terminal 3 to
control the first differential input circuit 13, the
second differential input circuit 14 and the third

differential input circuit 18 to start the operations. Also, the latch 2 receives the control signal D4' from the flip-flop circuit 19 receives the first differential input circuit 13, the second differential
5 input circuit 14 and the third differential input circuit 18 to stop the operations. When a plurality of sets of first register circuits 15 and a plurality of set of second register circuits 16 exist, the flip-flop circuit 19 outputs the control signal D4' to the
10 latch circuit 11 when the control signals D4 from all the sets of first register circuits 15 are obtained. In this case, the latch circuit 11 receive the control signal D4' and controls to stop the operations of the three differential input circuits 13, 14, 18.

15 Next, the structure and operation of the differential input circuits 13, 14 and 18 will be described.

First, the structure and operation of the first differential input circuit 13 will be described below.

20 Fig. 7 shows the structure of the first differential input circuit 13 in the horizontal drive type of semiconductor circuit according to the first embodiment of the present invention. Referring to Fig. 7, this embodiment of the first differential

25 input circuit 13 is composed of a terminal 21 that the potential is VDD ($VDD > 0$), a first circuit section 22, a second circuit section 23 and a waveform shaping

circuit section 24. Also, the differential input circuit 13 is connected with the drive circuit 30 of the external timing controller through the clock signal input terminals D2a-1 and D2a-2.

5 The terminal 21 is connected with the first circuit section 22 and the second circuit section 23. The first circuit section 22 is connected with the terminal 21, the waveform shaping circuit section 24, the clock signal input terminal D2a-1 and D2a-2 and
10 the node D5. The clock signal D2a is supplied from the clock signal input terminals D2a-1 and D2a-2. The first circuit section 22 has a first P-channel transistor 22a and a second P-channel transistor 22b. The source of the first P-channel transistor 22a and
15 the source of the second P-channel transistor 22b are connected with the terminal 21. The drain of the first P-channel transistor 22a is connected with the gate of the first P-channel transistor 22a, the gate of the second P-channel transistor 22b and the source
20 of a first N-channel transistor 22c. The drain of the first N-channel transistor 22c is connected with the drain of a third N-channel transistor 22e and the clock signal input terminal D2a-1. The source of the third N-channel transistor 22e is connected with the
25 source of a fourth N-channel transistor 22f and the ground potential 22g. The drain of the fourth N-channel transistor 22f is connected with the drain of

5 terminal 24a in the waveform shaping circuit section
24. Moreover, the gate of the second N channel
transistor 22d is connected with the gate of the first
N channel transistor 22c, the gate of the third N-
channel transistor 22e, the gate of the fourth N-
10 channel transistor 22f and the node D5.

The second circuit section 23 is connected with the terminal 21, the waveform shaping circuit section 24, the clock signal input terminal D2a-1 and D2a-2 and the node D5. The second circuit section 23 has a third P-channel transistor 23a and a fourth P-channel transistor 23b. The source of the third P-channel transistor 23a and the source of the fourth P-channel transistor 23b are connected with terminal 21. The drain of the third P-channel transistor 23a is connected with the drain of a fifth N-channel transistor 23c and a second terminal 24b of a current-voltage converting section 24. The source of the fifth N-channel transistor 23c is connected with the clock signal input terminal D2a-1. The gate of the fifth N-channel transistor 23c is connected with the gate of a sixth N-channel transistor 23d and the node D5. The drain of the sixth N-channel transistor 23d

is connected with the clock signal input terminal D2a-
2. The source of the sixth N-channel transistor 23d
is connected with the gate of the third P-channel
transistor 23a and the gate and drain of the fourth P-
5 channel transistor 23b.

The waveform shaping circuit section 24 is
connected with the second circuit section 23 at a
first terminal 24a and is connected with the first
circuit section 22 at a second terminal 24b. Also,
10 the waveform shaping circuit section 24 is connected
with the node D6. The waveform shaping circuit
section 24 has a first NAND gate 25, a second NAND
gate 26 and an inverter circuit 27. The first input
terminal of the first NAND gate 25 is connected with
15 the first terminal 24a. The first input terminal of
the second NAND gate 26 is connected with the second
terminal 24b. Also, the second input terminal of the
first NAND gate 25 is connected with the output of the
second NAND gate 26. Also, the output of the first
20 NAND gate 25 is connected with the second input
terminal of the second NAND gate 26 and the input
terminal of the inverter circuit 27. Moreover, the
output terminal of the inverter circuit 27 is
connected with an external terminal 31 connected with
25 the node D6. The clock signal D2a is supplied to the
drive circuit 30 of the external timing controller
through a terminal 29. Also, the drive circuit 30 of

the external timing controller is connected with the clock signal input terminal D2a-1 and the clock signal input terminal D2a-2.

The drive circuit 30 of the external timing controller is composed of an inverter circuit 28, a seventh N-channel transistor 30a and an eighth N-channel transistor 30b. The internal terminal 29 of the external timing controller is connected with the input terminal of the inverter circuit 28 and the gate of the seventh N-channel transistor 30a. The drain of the seventh N-channel transistor 30a is connected with the clock signal input terminal D2a-1. The source of the seventh N-channel transistor 30a is connected with the ground potential 30c and the source of the eighth N-channel transistor 30b. The gate of the eighth N-channel transistor 30b is connected with the output terminal of the inverter circuit 28. The drain of the eighth N-channel transistor 30b is connected with the clock signal input terminal D2a-2.

Next, an operation of the first differential input circuit 13 in this embodiment will be described. First, the case that the voltage level of the node D5 is zero will be described below. It is supposed that the voltage levels of the gates of the first N-channel transistor 22c, second N-channel transistor 22d, third N-channel transistor 22e and fourth N-channel transistor 22f are low in the first circuit section

22. In this case, therefore, a conductive state is not set between the source and the drain in each of the first N-channel transistor 22c, the second N-channel transistor 22d, the third N-channel transistor 22e and the fourth N-channel transistor 22f. As a result, the voltage level of the first terminal 24a does not change regardless of the ON and OFF states of the seventh N-channel transistor 30a and the eighth N-channel transistor 30b which depend on the change of the voltage level of the internal terminal 29 of the timing controller.

It is supposed that the voltage level of the gates of the fifth N-channel transistor 23c and sixth N-channel transistor 23d are low in the second circuit section 23. In this case, therefore, a conductive state is not set between the source and the drain of each of the fifth N-channel transistor 23c and the sixth N-channel transistor 23d. As a result, the voltage level of the second terminal 24b does not change regardless of the ON and OFF states of the seventh N-channel transistor 30a and the eighth N-channel transistor 30b which depend on the change of the voltage level of the internal terminal 29 of the timing controller. As a result, when the voltage level of the node D5 is zero, the voltage levels of the first terminal 24a and the second terminal 24b are fixed. Thus, an output voltage level of the external

terminal 31 of the first differential input circuit 13 is fixed.

Next, the case that the voltage level of the node D5 is V_B ($V_B > 0$) will be described below. It is supposed that the voltage levels of the gates of the first N-channel transistor 22c, second N-channel transistor 22d, third N-channel transistor 22e and fourth N-channel transistor 22f are V_B in the first circuit section 22. In this case, therefore, a conductive state is set between the source and the drain of each of the first N-channel transistor 22c, the second N-channel transistor 22d, the third N-channel transistor 22e and the fourth N-channel transistor 22f.

Next, it is supposed that the voltage levels of the gates of the fifth N-channel transistor 23c and the sixth N-channel transistor 23d are V_B in the second circuit section 23. In this case, therefore, a conductive state is set between the source and the drain of each of the third P channel transistor 23c and the fourth P channel transistor 23d. Here, if the clock signal D2a become low, the voltage of the gate of the seventh N-channel transistor 30a becomes high and the voltage of the gate of the eighth N-channel transistor 30b becomes low. Therefore, the conductive state is set between the source and the drain of the seventh N-channel transistor 30a, but the conductive

state is not set between the source and the drain of the eighth N-channel transistor 30b. As a result, the voltage level of the clock signal input terminal D2a-1 becomes a zero approximately and the clock signal input terminal D2a-2 becomes open.

In this case, in the first circuit section 22, since the conductive state is set between the source and the drain of the first N-channel transistor 22c, the voltage levels of the gates of the first P-channel transistor 22a and the second P-channel transistor 22b falls. Therefore, the conductive state is set between the source and the drain of each of the first P-channel transistor 22a and the second P-channel transistor 22b. Thus, the first terminal 24a is electrically connected with the terminal 21 and the potential of the first terminal 24a becomes the power supply voltage VDD.

Also, in the second circuit section 23, since a conductive state is set between the source and the drain of the fifth N-channel transistor 23c, the second terminal 24b is connected with the clock signal input terminal D2a-1. Therefore, the potential of the second terminal 24b becomes low.

In the above-mentioned case, in the waveform shaping circuit section 24, because the potential of the second terminal 24b is low, the voltage level of the output terminal of the second NAND gate 26 becomes

high. Next, the voltage levels of the output terminal of second NAND gate 26 and the voltage level of the first terminal 24a are high, the voltage level of the output terminal of the first NAND gate 25 becomes low.

5 As a result, the voltage levels of the second input terminal of the second NAND gate 26 and the input terminal of the inverter circuit 27 become low. Thus, the voltage level of the output terminal of the inverter circuit 27 becomes high and the voltage level
10 of the external terminal 31 becomes high.

Next, when the clock signal D2a is low, the voltage of the gate of the seventh N-channel transistor 30a becomes low so that the voltage of the gate of the eighth N-channel transistor 30b becomes
15 high. Therefore, the conductive state is set between the source and the drain of the eighth N-channel transistor 30b, but the conductive state is not set between the source and the drain of the seventh N-channel transistor 30a. Thus, clock signal input
20 terminal D2a-1 becomes open and the voltage level of the clock signal input terminal D2a-2 becomes a zero approximately. In this case, in the first circuit section 22, since the conductive state is set between the source and the drain of the second N-channel
25 transistor 22d, the clock signal input terminal D2a-2 and the first terminal 24a are electrically connected. Therefore, the potential of the first terminal 24a is

low.

Also, in the second circuit section 23, since the conductive state is set between the source and the drain of the sixth N-channel transistor 23d, the potentials of the gate of the third P-channel transistor 23a and the gate of the fourth P-channel transistor 23b fall. As a result, the conductive state is set between the source and the drain of each of the third P-channel transistor 23a and the fourth P-channel transistor 23b. Thus, the terminal 21 and the second terminal 24b are electrically connected. Therefore, the potential of the second terminal 24b becomes VDD.

In the above-mentioned case, in the waveform shaping circuit section 24, because the potential of the first terminal 24a is low, the voltage level of the output terminal of the first NAND gate 25 becomes high. Next, since the voltage level of the output terminal of the first NAND gate 25 and the voltage level of the second terminal 24b are high, the voltage level of the output terminal of the second NAND gate 26 becomes low. As a result, the voltage level of the output terminal of the first NAND gate 25 is fixed to the high level. Thus, the voltage level of the input terminal of the inverter circuit 27 becomes high, and the voltage level of the output terminal of the inverter circuit 27 becomes low. As a result, the

voltage level of the external terminal 31 becomes low.

Next, the structure and operation of the second differential input circuit 14 will be described below.

The structure and the operation of the second
5 differential input circuit 14 are same as those of the
differential input circuit 13 except that the first
data signal D2b is supplied from the external terminal
29 and the external terminal 31 is connected to the
first data registers 16a of the second register
10 circuit 16.

Next, the structure and operation of the third
differential input circuit 18 will be described below.
The structure and operation of the third differential
input circuit 18 are same as those of the differential
15 input circuit 13 except that the second data signal
D2c is supplied from the external terminal 29 and the
external terminal 31 is connected with the second data
registers 16b of the second register circuit 16.

Next, the horizontal drive type of
20 semiconductor circuit according to the second
embodiment of the present invention will be described.
The horizontal drive type of semiconductor circuit
according to the second embodiment differs from the
horizontal drive type of semiconductor circuit
25 according to the first embodiment in the structure of
the semiconductor circuit 2.

Fig. 8 shows the structure of the semiconductor

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5 the output terminal 4 of the semiconductor circuit 2
is connected with the shift register 15-j of the first
register circuit 15. In the semiconductor circuit
system in the second embodiment, the output terminal 4
of the semiconductor circuit 2 is connected with the

10 output terminal of the shift register 15-q of the
first register circuit 15 (q is an integer satisfying
 $1 \leq q \leq j-1$, and q=2 in the semiconductor circuit 2 of
the second embodiment). Other than this point, the
semiconductor circuit 2 in the second embodiment has
15 the same structure as the semiconductor circuit 2 in
the first embodiment. That is, in the semiconductor
circuit 2 in this second embodiment, the output
terminal 4 is connected with one of the shift
registers of the first register circuit 15 other than
20 the shift register 15-j. The shift register connected
with the output terminal 4 is not limited to the shift
register 15-2.

Next, the operation of the semiconductor circuit 2 in the horizontal drive type of semiconductor circuit system according to the second embodiment of the present invention will be described below. Referring to Figs. 9A to 9G, the pulse signal

P6 is supplied to the semiconductor circuit 2 from the input terminal 3. The voltage level of the control signal D3 changes into the VA in response to the rising edge of the pulse signal P6. The first
5 differential input circuit 13, the second the differential input circuit 14 and the third differential input circuit 18 start operation when the voltage level of the control signal D3 goes to VA.

Next, when a shift signal is outputted from the
10 flip-flop 15-2 to the output terminal 4, the output terminal 4 outputs a pulse signal P7. The pulse signal P7 as the control signal D4 is possible to be supplied to the other semiconductor circuits 2 in which the input terminal 3 is connected with the
15 output terminal 4.

Next, when a shift signal is outputted from the flip-flop 15-j to the flip-flop circuit 19, the flip-flop circuit 19 outputs a pulse signal P8 as the control signal D4' to the latch circuit 11. The latch
20 circuit 11 sets the voltage level of the control signal D3 to zero in response to the rising edge of the pulse signal P8. The first differential input circuit 13, the second the differential input circuit 14 and the third differential input circuit 18 pause
25 or stops the operation when the voltage level of the control signal D3 goes to zero.

In the horizontal drive type of semiconductor

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circuit system according to the second embodiment of the present invention, the number of driven semiconductor circuits 2 is at least two, and at most four. However, all the semiconductor circuits are never drive at the same time.

The first the differential input circuit 13 requires the time of 300 to 500 nanoseconds until it can operate stably after the voltage level of the node D5 changes into the high level. Also, the time necessary to write data in the first register circuit 15 and in the second register circuit 16 is equal to or less than 300 nanoseconds. Through the speed-up of the operation of the first register circuit 15 and second register circuit 16, the time necessary to write the data becomes shorter. Therefore, the semiconductor circuit 2 outputs the control signal D1 from the output terminal 4 300 to 500 nanoseconds after the control signal D1 is supplied to the input terminal 3. Also, the semiconductor circuit 2 stops the operation 300 nanoseconds after the control signal D1 is outputted from the output terminal 4. Therefore, three or more semiconductor circuits 2 are never driven at the same time.

In the semiconductor circuit 2 of the second embodiment shown, the latch circuit 11 controls to stop the operation of each of the plurality of the differential input circuits 13, 14 and 18 in response

to a pulse signal P8 from the flip-flop circuit 19.
When a plurality of first register circuits 15 exist,
the flip-flop circuit 19 outputs a pulse signal P8 as
the control signal D4' to the latch circuit 11 when
5 the shift signals are outputted from the flip-flops
15-j of all the first register circuits 15. In this
case, also, the latch circuit 11 controls the
plurality of the differential input circuits 13, 14
and 18 to stop the operation in response to the pulse
10 signal P8.

Next, the horizontal drive type of
semiconductor circuit system according to the third
embodiment of the present invention will be described
below. Fig. 10 shows the structure of the horizontal
15 drive type of semiconductor circuit system according
to the third embodiment of the present invention.

Referring to Fig. 10, the horizontal drive type
of semiconductor circuit 1 according to the third
embodiment of the present invention is composed of the
20 plurality of the semiconductor circuits 2-i ($i = 1, 2,$
..., n : n is an integer equal to or more than 3).
Each of the semiconductor circuits 2 has the input
terminal 3 and the output terminal 4.

The first input terminal 3-1 of the
25 semiconductor circuit 2-1, the first input terminal 3-
2 of the semiconductor circuit 2-2 and the first input
terminal 3-3 of the semiconductor circuit 2-3 are

connected with the first external terminal 5 which the control signal D1 is externally supplied. The first output terminal 4-1 of the semiconductor circuit 2-1 is connected with the input terminal 3-4 of the semiconductor circuit 2-4. The output terminal 4-2 of the semiconductor circuit 2-2 is connected with the input terminal 3-5 of the semiconductor circuit 2-5. The output terminal 4-3 of the semiconductor circuit 2-3 is connected with the input terminal 3-6 of the semiconductor circuit 2-6. The output terminal 4-m of the semiconductor circuit 2-m ($1 \leq m \leq n-3$) is connected with the input terminal 3-(m+2) of the semiconductor circuit 2-(m+3).

Also, each of the semiconductor circuits 2-1 is connected with the second external terminal 6 in which the voltage level is VB ($VB > 0$). The control signal D1 is outputted from the output terminal 4-m of the semiconductor circuit 2-m and is supplied to the input terminal 3-(m+3) of the semiconductor circuit 2-(m+3). Also, a data signal and a clock signal (both not shown) are externally supplied to each of the semiconductor circuits 2-1.

Next, an operation of the horizontal drive type of semiconductor circuit system according to the third embodiment of the present invention will be described. Figs. 11A to 11K are the time charts showing the operation of the horizontal drive type of

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semiconductor circuit system according to the third embodiment of the present invention. Referring to Figs. 11A to 11K, a pulse signal P9 is supplied from the first external terminal 5 to the horizontal drive

5 type of semiconductor circuit system 1. The semiconductor circuits 2-1 activated in response to the rising edge of the pulse signal P9. When a data writing operation ends, the semiconductor circuit 2-1 outputs a pulse signal P10 from the output terminal 4-1 and pauses or stops the operation. The semiconductor circuit 2-4 is activated in response to the rising edge of pulse signal P10. When a data writing operation ends, the semiconductor circuit 2-2 outputs the pulse signal P10 from the output terminal 4-2 and pauses or stops the operation. The semiconductor circuit 2-5 is activated in response to the rising edge of pulse signal P10. When a data writing operation ends, the semiconductor circuit 2-3 outputs a pulse signal P11 from the output terminal 4-3 and pauses or stops the operation. The semiconductor circuit 2-6 is activated in response to the rising edge of pulse signal P11. In the same way, when a data writing operation ends, the semiconductor circuit 2-m outputs a pulse signal from the output terminal 4-m and pauses or stops the operation. The semiconductor circuit 2-(m+2) is activated in response to the rising edge of the pulse signal outputted from

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the output terminal 4-m. Also, when a data writing operation ends, the semiconductor circuit 2-m pauses or stops the operation.

In the horizontal drive type of semiconductor circuit system according to the third embodiment of the present invention, at most three semiconductor circuits are driven. The differential input circuit which is provided for the semiconductor circuit 2 used in the horizontal drive type of semiconductor circuit system according to the third embodiment of the present invention and the semiconductor circuit 2 is the same as that which is used in the horizontal drive type of semiconductor circuit system according to the first embodiment of the present invention.

15 Next, the horizontal drive type of semiconductor circuit system according to the fourth embodiment of the present invention will be described. The horizontal drive type of semiconductor circuit system according to the fourth embodiment of the present invention differs from that of the third embodiment of the present invention in the structure of the semiconductor circuit 2.

The semiconductor circuit 2 which is used in the horizontal drive type of semiconductor circuit system according to the fourth embodiment of the present invention is the same as that which is used in the horizontal drive type of semiconductor circuit

system according to the second embodiment of the present invention. Therefore, in the horizontal drive type of semiconductor circuit system according to the fourth embodiment of the present invention, at most six semiconductor circuits 2 are driven at the same time and all the semiconductor circuits 2 are never driven at the same time.

Also, the horizontal drive type of semiconductor circuit system of the present invention is not limited to the embodiments shown in the above. It is sufficient if the horizontal drive type of semiconductor circuit system has the structure shown below. The horizontal drive type of semiconductor circuit system is composed of the plurality of semiconductor circuits 2-i ($i = 1, 2, \dots, n$; n is an integer equal to or more than 3). Each of the semiconductor circuits 2 has the input terminal 3 and output terminal 4. Each of the input terminals 3 of the semiconductor circuits 2-r ($1 \leq r < n$) is connected with the first external terminal 5 in which the control signal D1 is externally supplied. Also, the output terminal 4-s of the semiconductor circuit 2-s ($1 \leq r+s \leq n$) is connected with the input terminal 3-(r+s) of the semiconductor circuit 2-(r+s).

25 As described above, the present invention has
the following advantages.

The conventional horizontal drive type of

semiconductor circuit system is composed of 10 semiconductor circuits. Also, each of the semiconductor circuits has 15 differential input circuits and 15 logic circuit sections. The power consumption of one differential input circuit is 1 mA in a standing-by mode and in an operation mode. Therefore, the consumption current of the differential input circuits of one semiconductor circuit is 15 mA in a standing-by and an operation mode of the semiconductor circuit. Also, the consumption current of the logic circuit section is 10 mA in the operation mode and 0 mA in the standing-by mode. Therefore, when the horizontal drive type of semiconductor circuit system shown in Fig. 2 is drives, the consumption current is $(15\text{mA} + 10\text{mA}) \times 10$ (the number of circuits) and shown as 250 mA, for all of 10 semiconductor circuits to be driven.

Also, in case of the horizontal drive type of semiconductor circuit system according to the first embodiment of the present invention shown in Fig. 4, only two of the semiconductor circuits are driven, and the consumption current is $(15\text{mA} + 10\text{mA}) \times 2$ (the number of the chips) and shown as 50 mA. In this way, in the horizontal drive type of semiconductor circuit system of the present invention, the consumption current can be reduced, compared with the conventional horizontal drive type of semiconductor circuit system

Also, all the semiconductor circuits are always driven in the horizontal drive type of semiconductor circuit system of the present invention. Therefore, it is possible to reduce the drive capability of the drive transistor provided in the timing controller to output a clock signal and a data signal.

Specifically, in the horizontal drive type of semiconductor circuit system according to the first embodiment of the present invention, at most two of the semiconductor circuits are only driven at the same time. Therefore, the drive transistor in the timing controller is sufficient to have the drive capability necessary to drive two semiconductor circuits. Also, in the conventional horizontal drive type of semiconductor circuit system shown in Fig. 2, all of 10 semiconductor circuits are driven. Therefore, the drive transistor of the timing controller needs to have the drive capability necessary to drive 10 semiconductor circuits. In the horizontal drive type of semiconductor circuit system of the present invention, the drive transistor of the timing controller is sufficient to have the drive capability of about 1/5 of the drive capability of the drive transistor. As a result, in the horizontal drive type of semiconductor circuit system of the present invention, the size of the transistor can be made

small.

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